

Embedded Control of Electric Vehicle Motor System

EGH456 Embedded Systems

Supporting Material

The specifications in this document are subject to change

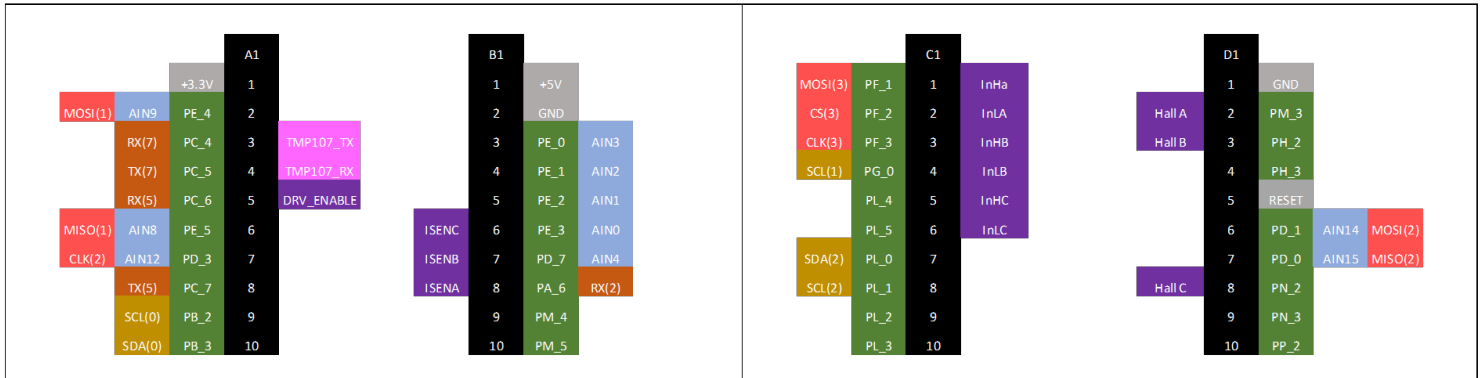
1. Assumptions

This document assumes that the Motor driver and adapter board have been installed on Boosterpack 1 (on the Tiva Launchpad) and that the Sensor and LCD Touchscreen have been installed on Boosterpack 2 (on the Tiva Launchpad). Please see the testing station kit image (see assignment specification document) for an example of how the boosterpack hardware should be installed on the Tiva launchpad kit.

2. Pinout Diagram

Figure 1 and 2 provides a pinout diagram of the headers for boosterpack 1 & 2, highlighting pins relevant for this assignment and associated connected devices. This is a subset of the pinout of the boosterpack 1 and 2 interfaces. If more details are needed for the pinouts of the boosterpack 1 and 2 headers, please refer to the EK-TM4C1294XL user guide and datasheet. The boosterpack headers have a left and right header each containing two rows of pins. Each individual diagram below shows either the left and right side of the boosterpack 1 or 2 header and then illustrates the two rows of pins by highlighting them on either the left or right of the diagram.

The pin maps below should be used to identify any potential conflicts with using pins that are shared across multiple devices. For example the touchscreen drivers may not operate correctly if you reconfigure the ADC pins required to measure the touch position on the screen.

BOOSTERPACK 1**Legend**

Tiva Pin Functions	Boosterpack Boards
PIN NAME	BOOSTXL-SENSORS
ANALOG	LCD SCREEN
SERIAL UART	BOOSTXL-DRV8323RH
SPI	MOTOR CONNECTOR BOARD
I2C	

Figure 1: Pin Map of Booster Pack 1, Header A, B 1-10 (Left Side)

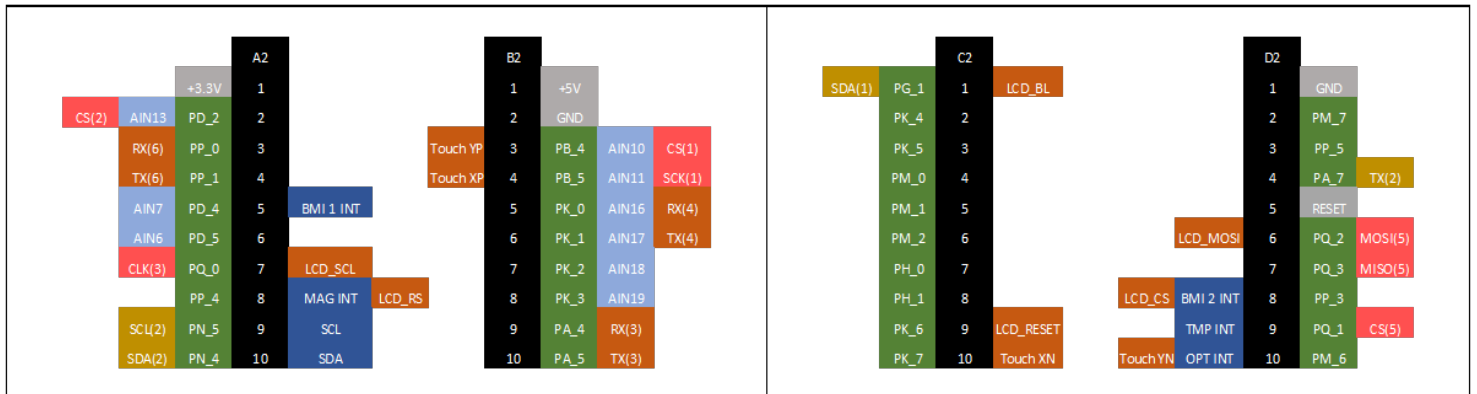
BOOSTERPACK 2

Figure 2: Pin Map of Booster Pack 2, Header A, B 1-10 (Left Side)

Figures 1 and 2 display key pins associated with various functions for the assignment. This is for use as a quick reference only and may not contain all required information. Consult appropriate datasheets for complete data. Booster pack 1, shown in Figure 1, refer to the headers that should have the motor kit installed on. Booster pack 2, shown in Figure 2 refer to the headers which the touch screen and sensor booster pack is on.

3. Devices Utilised

Part Name	Part Number	Details
Tiva C Launchpad	EK-TM4C1294XL	Development Board featuring TM4C series microcontroller
Booster Pack K350QVG	BOOSTXL-K350QVG-S1	LCD Display and Resistive Touch Screen Interface
Sensors Boosterpack	BOOSTXL-SENSORS	Sensor board which includes a BMI160 Accelerometer & Gyro, BMM150 Compass, OPT3001 Ambient Light Sensor and BME280 Environment Sensor
Three-Phase Smart Gate Driver	DRV8323	Motor Control
EGH456 Motor Adapter Board V2.2	NA	Interface and current protection to Brushless Motor. Provides RX/TX connection to ambient and motor TMP107 Temperature Sensor
Maxon Three Phase Motor	267121	Motor

4. Motor State Diagram

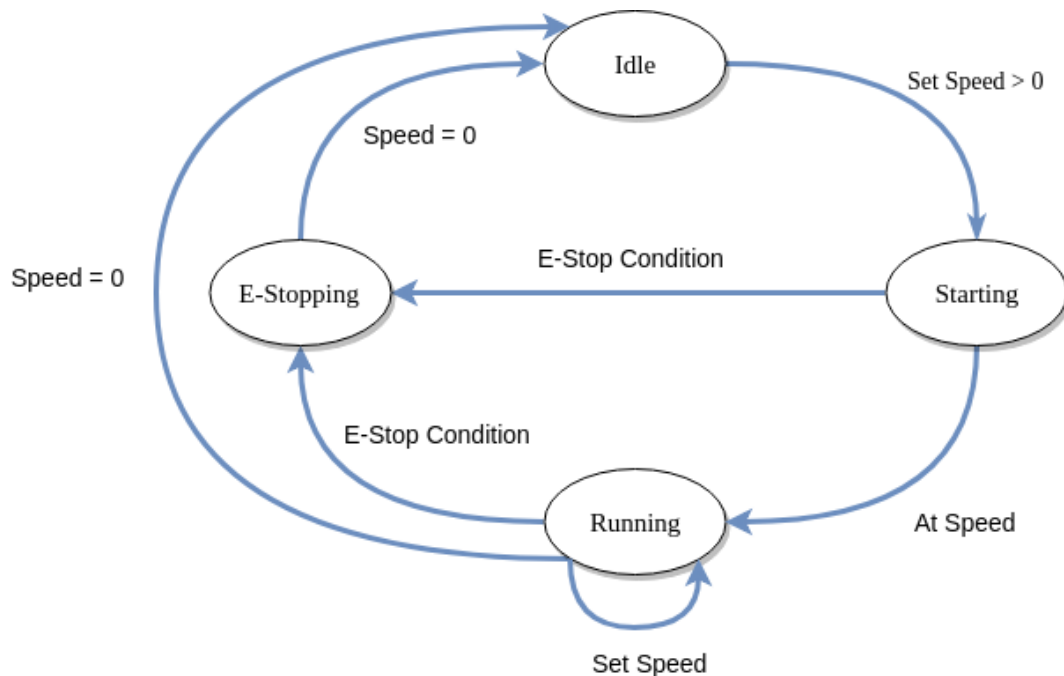


Figure 3: State Diagram for Controlling the Motor

Figure 3 shows the state machine that the motor controller should follow when starting and stopping the motor. See the assignment document for a description of when E-stop conditions have occurred.

5. Speed Control Diagram

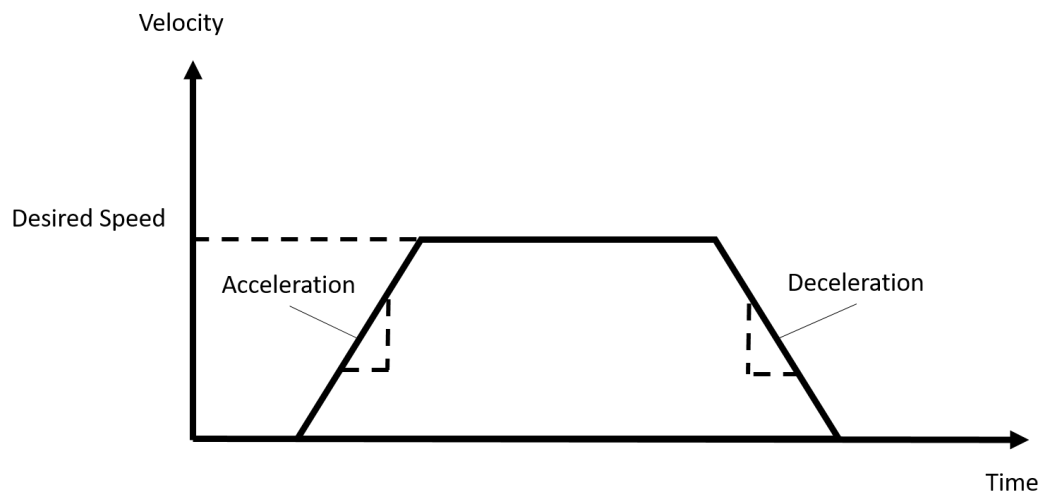


Figure 4: Diagram for Controlling the Speed of the Vehicle

Figure 4 indicates the desired behaviour of the speed control system. The acceleration and deceleration should be used to change the speed of the motor to the desired speed. Note that there is a different deceleration requirement depending on whether an e-stop condition has occurred.

6. Motor Phase Diagram

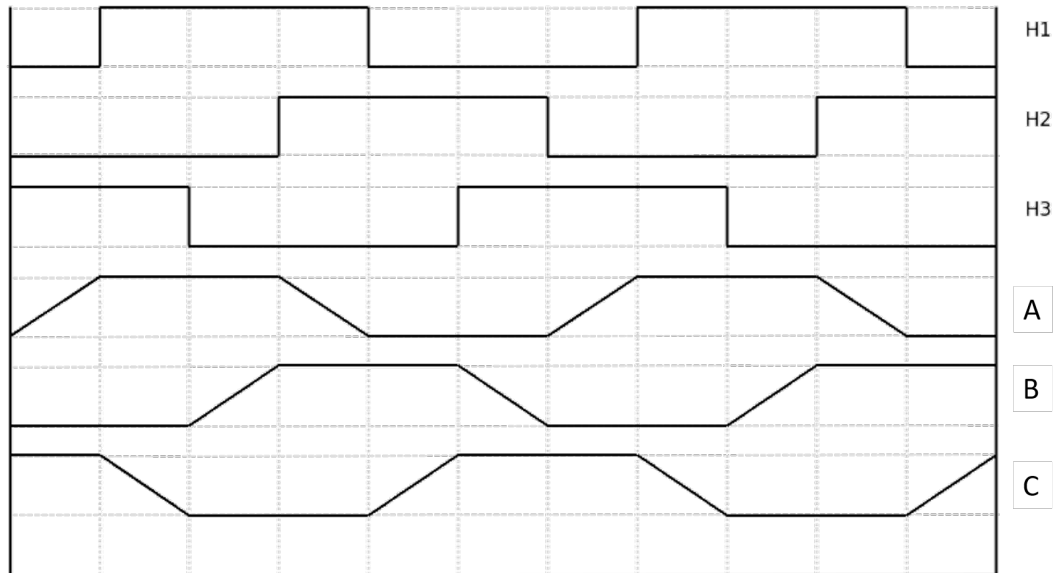


Figure 5: Phase Diagram for Driving the Motor

Figure 5 shows the different phases and hall effect sensor state diagram of the 3 phase brushless DC motor. Depending on the number of pole pairs for a brushless motor this corresponds to a different number of degrees of rotation for the motor. This diagram can be used to determine how to drive each phase (high or low) of the motor depending on the state of the hall effect sensors. H1, H2 and H3 indicate the voltage level of the each hall effect sensors which indicate the current position of the motor. A, B and C indicate the corresponding required voltage of the three phases of the brushless motor. For example, during the initial phase, H1 and H2 are low and H3 is high which corresponds to driving phase B low, phase C high and leaving phase A floating (indicated by the ramped voltage). Think of this diagram as a state machine where each column (indicated by the vertical dotted lines) is a state depending on the hall effect sensors and the transition occurs when a change in a hall effect sensor occurs. For every hall effect transition the motor phases need to be updated by calling the `updateMotor()` function within the motor library. It is recommended to do this within an interrupt handler routine.

7. Tips and Additional Info

Motor Kit

The DRV8232 Motor Driver Kit has the following settings (Please see the DRV8232RH datasheet for more detail):

- The GAIN pin has been tied to GND with a 47k resistor so has a gain of 10 for the current amplifier
- The current shunt resistor values are 0.007 Ohms for each current sense line. See section 8.3.4.1 for an equation to calculate current from the voltage measurement
- Vref is 3.3V for the motor driver and VSOx is the voltage that you are measuring.

Sensors

Feel free to use opensource libraries for sensors if they are available. Some examples can be found in the sensorlib folder within Tivaware (C:\ti\tivaware_c.series_2.1_4.178\sensorlib).

Motor Library

Use the error block argument to check if PWM hardware is failing to be created. You can see the error message by inspecting the return eb.msg value. Ensure you don't use timer0 in your implementation as the motor library uses this timer.

Touch Screen

The touchscreeninhandler needs to be setup within a hwi for it to work within the TI-RTOS framework. Use int number 33 as the interrupt. Alternatively, add these lines to your .cfg file to setup a hwi statically for your touchscreen:

```
var halHwi0Params = new halHwi.Params();
halHwi0Params.instance.name = "TouchScreenIntHandlerHandle";
Program.global.TouchScreenIntHandlerHandle =
    halHwi.create(33, "&TouchScreenIntHandler", halHwi0Params);
```

The touchscreen also uses ADC0 within its implementation so make sure you don't cause conflict by using ADC0 for current sensing. Timer 1 is used by the touch screen so make sure you also don't use it for your application, or it will interfere with the touch interface

TI-RTOS & Tivaware Conflicts

One issue that can come up is when trying to use Tivaware IntRegister functions to setup interrupt handlers. This actually corrupts the interrupt vector table that the TI-RTOS libraries sets up via the Hwi module. Make sure to not use IntRegister but use Hwi_create instead to register interrupt functions with their respective vector numbers.

Reference Documents

- [DRV832x 6 to 60-V Three-Phase Smart Gate Driver Datasheet](#)
- [DRV832XX EVM Sensored Software User's Guide](#)
- [BOOSTXL-DRV8323Rx EVM User's Guide](#)
- [TI-RTOS User's Guide](#)
- [TI-RTOS SYS/BIOS User's Guide](#)
- [EK-TM4C1294XL User's Guide](#)
- [TM4C1294NCPDT Datasheet](#)
- [OPT3001 Ambient Light Sensor Datasheet](#)
- [BOOSTXL-SENSORS Sensors BoosterPack User's Guide](#)
- [Grove IR Temperature Sensor - OTP-538U](#)
- [Grove Time of Flight Distance Sensor - VL53LOX](#)